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Claims

[c1] A method of determining a physical characteristic associated with a plurality of layers of a laminated formation traversed by a wellbore, said method comprising the steps of:
providing one or more high resolution logs of a formation property for the laminated formation;
from a high resolution log, detecting the bed boundaries of the laminated formation, thereby detecting the individual beds disposed between the boundaries;
importing a set of defined facies associated with the laminated formation, including importing a volumetric description with each of the defined facies;
assigning one of the defined facies, and the volumetric description associated therewith, to each of the beds detected;
generating at least one squared log for a formation property, including using imported volumetric descriptions of the facies for a plurality of beds to generate a value of the formation property for each of the beds;
comparing the squared log with a measured log of the formation property for the laminated formation;
adjusting the values of the squared log; and

repeating, one or more times, said adjusting and comparing steps before selecting an adjusted squared log as an optimized square log of the formation property.

[c2] The method of Claim 1, further comprising the step of performing a volumetric analysis on the optimized squared log.

[c3] The method of Claim 2, further comprising the step of storing, on an output record medium, the optimized squared log and the corresponding volumetric analyses of the squared log, the volumetric analyses illustrating each layer of the plurality of layers of the laminated formation.

[c4] The method of Claim 3, wherein the laminated formation includes thin beds, said storing step including storing volumetric analyses that includes an illustration of each of the thin bed layers in the laminated formation.

[c5] The method of Claim 1, wherein said step of generating a squared log includes determining minimum and maximum constraints for the formation property values for a plurality of the beds, the minimum and maximum constraints being derived from the imported volumetric descriptions associated with each bed, and wherein said adjusting step includes adjusting the values of the

squared log within corresponding minimum and maximum constraints.

[c6] The method of Claim 1, wherein said comparing step includes generating a reconstructed log from the squared log and comparing the reconstructed log with the measured log; and
wherein said adjusting step includes adjusting the values of the squared log to minimize the difference between the reconstructed log and the measured log.

[c7] The method of Claim 6, wherein said step of generating at least one squared log includes generating a plurality of squared logs of different formation properties and wherein, each of the comparing and adjusting steps are performed in respect to a plurality of reconstructed logs generated from the plurality of squared logs and a plurality of measured low resolution logs for the different formation properties, thereby selecting a plurality of optimized squared logs.

[c8] The method of Claim 7, wherein each of said comparing and adjusting steps is performed simultaneously in respect to the plurality of generated reconstructed logs and the plurality of measured low resolution logs.

[c9] The method of Claim 7, further comprising the steps of:

performing a volumetric analysis on the plurality of optimized squared logs; and

on an output medium, the optimized squared logs and a volumetric analysis for each of the beds of the laminated formation, the volumetric analyses illustrating each of the layers of the laminated formation.

[c10] The method of Claim 7, wherein said step of generating a reconstructed log includes employing a convolution filter to convolve the squared log.

[c11] The method of Claim 1, wherein said step of detecting bed boundaries include detecting the boundaries for a plurality of thin beds, and wherein said assigning step includes assigning one of the defined facies to one of the thin beds.

[c12] The method of Claim 11, wherein said assigning step includes squaring the high resolution log;

obtaining a property value, from the high resolution log, for each of the thin beds; and

matching the value with a value derived from a volumetric description associated with one of the defined facies, thereby assigning said one of the defined facies with said thin bed.

[c13] The method of Claim 12, wherein said assigning step in-

cludes assigning each of the thin beds a volumetric description derived from a thick bed located in the same laminated formation.

[c14] The method of Claim 12, wherein said squaring, obtaining, and matching steps of the assigned step is applied to a plurality of high resolution logs and a corresponding plurality of property values, thereby assigning a defined facies with the thin bed.

[c15] The method of Claim 1, wherein said importing step includes importing defined facies associated with thick beds in the same laminated formation.

[c16] The method of Claim 1, wherein said step of generating a squared log includes computing an initial property value for a bed from the volumetric description assigned to the bed.

[c17] A method of estimating the values of a formation property for a plurality of layers of a laminated formation, the laminated formation having thin beds therein and traversed by a wellbore, said method comprising the steps of:

detecting the bed boundaries of the laminated formation, thereby detecting the individual beds disposed between the boundaries including the thin beds;

importing a set of defined facies associated with the laminated formation, including importing a volumetric description for each of the defined facies; and
estimating a value of the formation property for a plurality of the thin beds, including, for each of the plurality of thin beds, computing a value of the formation property from one of the imported volumetric descriptions.

[c18] The method of claim 17, further comprising the step of generating at least one squared log of the formation property by performing said estimating step for a plurality of the detected beds .

[c19] The method of Claim 18, further comprising the steps of:
optimizing the squared log of the formation property, including
generating a reconstructed log from the squared log;
comparing the reconstructed log with a measured log for the laminated formation; and
adjusting the values of the squared log to minimize the difference between the reconstructed log and the measured log, thereby generating an optimized squared log.

[c20] The method of Claim 19, wherein said estimating step computes the initial property value for each of the beds, prior to said optimizing step.

[c21] The method of Claim 19, further comprising the step of performing a volumetric analysis on the optimized squared log and displaying the volumetric analysis on an output record medium, the volumetric analysis illustrating each layer of the laminated formation including the thin beds.

[c22] The method of Claim 17, further comprising the step of assigning one of the defined facies, and the volumetric description associated therewith, to each of the plurality of thin beds, said computing step including computing the value from the volumetric description assigned to the thin bed.

[c23] The method of Claim 22, wherein said detecting step includes providing one or more high resolution logs of a formation property, and, from the high resolution log, detecting the bed boundaries.

[c24] The method of Claim 23, wherein said assigning step includes the steps of:
squaring the high resolution log;
obtaining a property value, from the high resolution log, for each of the thin beds; and
matching the obtained value with a value derived from a volumetric description associated with one of the defined

facies, thereby assigning the defined facies with the thin bed.

[c25] The method of Claim 24, wherein each of said squaring, obtaining, and matching steps is applied to a plurality of high resolution logs and a corresponding plurality of property values, thereby assigning a defined facies with the thin bed.

[c26] The method of Claim 19, wherein said step of at least one squared log includes generating a plurality of squared logs of different formation properties and wherein, each of the comparing and adjusting steps are performed in respect to a plurality of reconstructed logs generated from the plurality of squared logs and a plurality of measured low resolution logs for the different formation properties, thereby selecting a plurality of optimized squared logs.

[c27] The method of Claim 26, further comprising the steps of:performing a volumetric analysis on the optimized squared logs; anddisplaying, on an output medium, the optimized squared logs and a volumetric analysis on the optimized squared logs for each of the beds of the laminated formation, the volumetric analyses illustrating each of the layers of the laminated formation.

[c28] The method of Claim 19, wherein said step of generating a squared log includes determining minimum and maximum constraints for the formation property values for various facies, the minimum and maximum constraints being derived from imported volumetric analysis, and wherein said adjusting step includes adjusting each of the values of the squared log within corresponding minimum and maximum constraints.

[c29] The method of Claim 28, wherein said step of generating a squared log includes computing an initial property value for a bed from the volumetric description assigned to the bed.

[c30] A computer implemented method of estimating the values of a formation property associated with a plurality of layers of a laminated formation traversed by a wellbore, said method comprising the steps of:
inputting one or more high resolution logs of a formation property for the laminated formation;
from a high resolution log, detecting the bed boundaries of the laminated formation, thereby detecting the individual beds disposed between the boundaries;
accessing a set of defined facies associated with the laminated formation, including importing a volumetric description with each of the defined facies;
assigning one of the defined facies, and the volumetric

description associated therewith, to each of the beds detected;

generating at least one squared log for a formation property, including using imported volumetric descriptions of the facies for a plurality of beds to generate an initial value of the formation property for each of the beds;

comparing the squared log with a measured log of the formation property for the laminated formation;

adjusting the values of the squared log; and

repeating, one or more times, said adjusting and comparing steps to output an adjusted squared log as an optimized square log of the formation property;

wherein said step of generating a squared log includes determining minimum and maximum constraints for the formation property values for a plurality of the beds, the minimum and maximum constraints being derived from the imported volumetric descriptions assigned with each bed, and wherein said adjusting step includes adjusting the values of the squared log within corresponding minimum and maximum constraints.

[c31] The method of Claim 30, further comprising the steps of:

performing a volumetric analysis on the optimized squared log; and

storing, on an output record medium, the optimized squared log and the corresponding volumetric analyses of the squared log, the volumetric analyses illustrating each layer of the plurality of layers of the laminated formation.

[c32] The method of Claim 31, wherein the laminated formation includes thin beds, said storing step including storing a volumetric analyses that includes an illustration of each of the thin bed layers in the laminated formation.

[c33] The method of Claim 30, wherein said comparing step includes generating a reconstructed log from the squared log and comparing the reconstructed log with the measured log; and
wherein said adjusting step includes adjusting the values of the squared log to minimize the difference between the reconstructed log and the measured log.

[c34] The method of Claim 33, wherein said step of generating at least one squared log includes generating a plurality of squared logs of different formation properties and wherein, each of the comparing and adjusting steps are performed in respect to a plurality of reconstructed logs generated from the plurality of squared logs and a plurality of measured low resolution logs for the different formation properties, thereby selecting a plurality of op-

timized squared logs.

[c35] The method of Claim 30, wherein said step of detecting bed boundaries includes detecting the boundaries for a plurality of thin beds, and wherein said assigning step includes assigning one of the defined facies to a plurality of thin beds.

[c36] The method of Claim 35, wherein said assigning step includes,
squaring the high resolution log;
obtaining an initial property value, from the high resolution log, for each of the thin beds; and
matching the value with a value derived from a volumetric description associated with one of the defined facies, thereby assigning the defined facies with the thin bed.

[c37] The method of Claim 36, wherein said assigning step includes assigning each of the thin beds a volumetric description derived from a thick bed located in the same laminated formation.

[c38] The method of Claim 36, wherein said squaring, obtaining, and matching steps is applied to a plurality of high resolution logs and a corresponding plurality of property values, thereby assigning a defined facies with the thin bed.